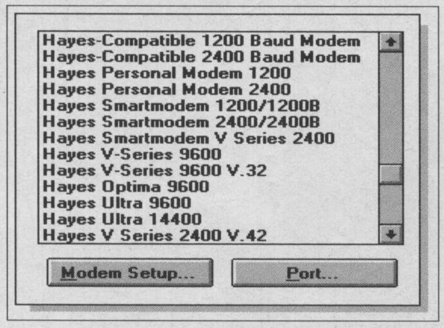
Are you confused by all the features and modes offered by the latest high-speed modems? Tony Dennis explains what they do, how they work, and whether or not you will need them.

MOVE INTO THE FAST LINE



Competition among manufacturers has helped to produce radical improvements in the speed and accuracy with which data can be pumped down a standard telephone line. The black box which allows all this to happen is known as a modem, and in this article we'll take a look at some of the techniques which have seen a modem's top speed increase tenfold in the same number of years.

In essence a modem allows two computers to 'talk' over an ordinary telephone line. The telephone system was, of course, originally designed to carry speech, not computer communications, so the signals it carries are in an analog form rather than digital. A sending modem takes digital input and uses it to modulate an analog carrier signal. At the other end of the line, a receiving modem translates, or demodulates, the analog signals back into digital form. The word 'modem' is short for MOdulator – DEModulator.

Understandably, the most efficient manner of using a standard telephone line is to imitate the human voice. So the analog signals that modems use are quite audible. In fact what a pair of modems are really doing when they are 'modulating', is whistling at each other!

In order for two modems to be able to communicate, they must be able to speak the same language. In technical terms this means they must be capable of supporting at least one common standard. Fortunately, the art of modem communication has stabilised and the vast majority of manufacturers utilise standards set by the CCITT (an international telecommunications body). These standards are called the 'V series' so a modem's capabilities are expressed in terms of their support for V21, V22 or V32 bis, and so on.

BITS AND BAUDS

One area which has traditionally caused a great deal of confusion concerns the way in which a modem's speed is expressed. Ten years ago it was common practice to talk about a modem's baud rate. These days a modem's performance is judged by its data throughput in terms of bits per second.

Most of the confusion arises because originally these two measures were interchangeable. A baud rate is actually a measure of modulation, so the carrier of a 300 baud modem goes through 300 modulations every second. With early modems each modulation was used to transfer just one bit of data, so a 300 baud modem provided an effective throughput of 300 bits per second (commonly abbreviated to 300 bps).

Any modem connection is, however, a two way process. So with a 300 baud modem (a V21 modem, in other words) there is one transmitting channel and one receiving channel, each modulating at 300 baud.

The carrier for the transmit channel modulates between 980 and 1,180Hz, representing either a one or a zero, while the receive carrier modulates between 1,650Hz and 1,850Hz. If either carrier signal disappears both modems take it as a sign that the link has been broken and so stop communicating.

FAST WORK

Naturally, engineers soon got to work and began to design faster modems. One route was obvious – modulate the carrier at a higher speed. The snag is that a telephone line has a limited bandwidth and can only really accept modulations up to around 1400 baud.

British Telecom came up with a special type of modem capable of receiving data at 1200 baud but it transmitted at only 75 baud, just about within the capabilities of the system. In fact 75 baud is about the speed that a decent typist can hit the keyboard, so this system proved ideal for BT's Prestel system, where the majority of information is transmitted one way – from the Prestel computer to the user. Modems capable of this kind of operation are called V23 modems.

But what happens if two PCs want to swap files? V23 modems can take it in turns to be in charge of the 1200 baud channel, in a 'pseudo full duplex' fashion. A full duplex modem is capable of sending and receiving data at the same time while a half duplex modem only has one channel, which allows data to travel only in one direction at a time.

What the world really wanted was a modem able to provide 1200 baud communications simultaneously in both directions. However, this couldn't be achieved using frequency modulation, or frequency shift keying (FSK). The solution was to modulate the phase of the carrier, rather than its frequency. The V22 standard uses differentiated phase shift keying (DPSK) to modulate a carrier of 1,200Hz for the transmit channel and 2,400Hz for the receive. However, DPSK differentiates between four different phase angles which means that each modulation can transfer two bits of data, rather than one. In this way, two 600 baud channels can provide full duplex commu-

nication at 1,200 bps (see diagram, right).

To achieve even higher speeds manufacturers started playing with the amplitude or volume of each signal as well. For the V22 bis standard, both FSK and DPSK gave way to a mixture of amplitude and phase modulation known as Quadrature Amplitude Modulation (QAM). This differentiates between twelve phase angles, rather than four, and three amplitude levels which means that four bits of data can be transferred for each modulation. Incidentally bis is based on the Latin word for twice and indicates the second version of a standard, not that it's twice as fast!

One way to get higher speeds was to go back to Prestel days and have one high speed channel, say 9600 bps, and another slower channel operating in the opposite direction. This proved ideal for another kind of device – the fax machine. In effect, fax machines have 9600 bps modems in them but with the high speed channel only operating in one direction at a time.

Thanks to fax, 'pseudo full duplex' reared its ugly head again. Manufacturers who decided to introduce such modems based on this technique included Hayes and Miracom, but sadly no-one could agree a standard. The result is the HST mode in Miracom modems and what is now called Express 96 in the Hayes Smartmodem 2400 modems (also found in the old Smartmodem 9600 which has now been replaced by the Ultra range). A more beneficial side effect is that modem manufacturers decided to offer modems with an ability to communicate at 9600 bps using fax standards, and so communicate with dedicated fax machines as well as ordinary modems.

Meanwhile the race was on to produce a proper full-duplex 9600 bps modem. It was achieved through a scheme called Trellis encoding. Here both modems transmit an extra pattern of bits, along with the data. If one bit gets lost along the way, the receiving modem uses the pattern to work out what the bit should have been by filling in the holes in the trellis. The V32 standard gives true 9600 bps and is only now being replaced by V32 bis, which can operate at 14,400 bps (14.4k bps). Over the horizon are modems which will conform to a standard known as V.Fast, able to achieve speeds of 28.8k bps. Miracom promises one before the end of 1992.

ERROR CORRECTION

When 2400 bps modem were first introduced, users soon noticed that noise on the line meant the real throughput speed dropped to a figure closer to 1400 bps. The answer was to borrow a technique which bulletin board fanatics had already introduced – error correction.

In order to ensure that a file could be transmitted error free from one computer to another, Ward Christensen and Randy Suess invented an error correction file transfer protocol called Xmodem.

With Xmodem a file is broken down into small, manageable chunks. The sending computer sends the first block and then asks, 'Did you get that OK?' If everything went well the receiver sends an acknowledgement (ACK), but if the block contains errors the computer sends a negative acknowledgement (NACK) and the block is then re-sent. This process relies on bad blocks being re-sent automatically and has therefore been termed 'automatic request to send' or ARQ.

When PC users communicate through bulletin boards they only use ARQ when they are actually downloading or uploading files, but some bright spark came up with the idea of using ARQ techniques the whole time by actually building it into the modems. ARQ first appeared in this country with the original Dowty modems.

There was one major drawback to all this error correction, in that it was taking up a lot of processing time and so slowing down the rate at which data was being transmitted in the first place.

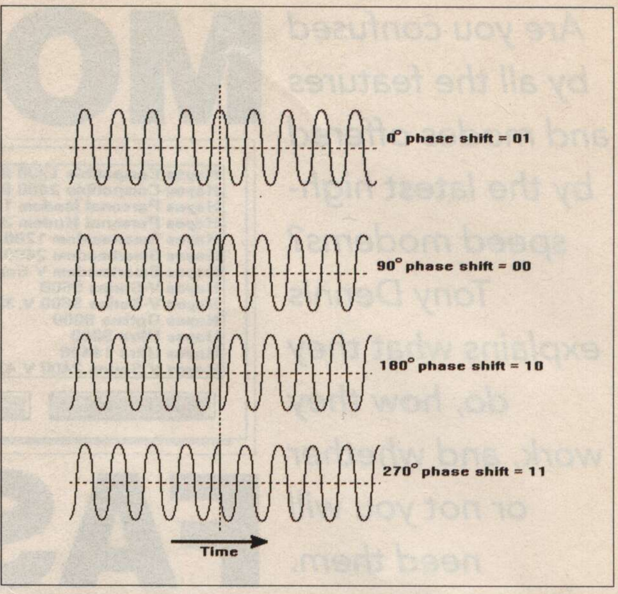
One of the first means of tackling the problem was to put a dedicated microprocessor and a little bit of memory inside the modem. Another technique involved fine tuning the error correction protocol by playing with the size of blocks and ignoring the ACK signals. If you have bigger blocks, data can be sent more swiftly because there are fewer ACK and NACK signals to process.

Ignoring ACKs means that you don't wait before sending the next block, but instead store up all the received NACKs and then re-send the blocks which were bad at the end of the process.

One company which was hugely successful in marketing such modems was Microcom. The company invented a set of protocols which go under the generic name of Microcom Networking Protocols (MNP). These evolved over time, eventually culminating in the popular MNP Level 4 standard.

DATA COMPRESSION

There was a radical change when MNP5 was introduced, however. This move mirrored another popular technique from the bulletin board world. Users had noticed that



● With differential phase shift keying (DPSK) the receiving modem can differentiate between four phase shifts on each modulation, by assigning these the codes 00, 01, 10 and 11, two bits of binary data can be transferred for each modulation. Higher rates of transfer can be achieved by using a finer phase differential and by modulating the amplitude of the carrier as well as its phase.

THE V SERIES

V number	Bit rate	Baud rate	Modulation	Duplex
V21	300	300	FSK	Full
V23	1,200/75	1,200	FSK	Full
V23	1,200	1,200	FSK	Half
V22	1,200	600	DPSK	Full
V22 bis	2,400	600	QAM	Full
V29	9,600	600	QAM	Half
V32	9,600	600	QAM	Full
V32 bis	14,400	600	QAM	Full

MNP4	Microcom error correction Protocol
MNP5	Microcom's proprietary data compression system
V42	LAP/M and MNP4 error correction
V42 bis	BTLZ data compression

● These are four of the latest high speed modems, incorporating error checking and data compression.

most files contain a lot of redundant or duplicated information, so it became common practice to compress a file using special compression algorithms before sending it over the telephone line. If a file can be compressed to one quarter of its original size then the phone bill for downloading it is cut to a quarter too.

A whole host of data compression utilities such as PKARC had sprung into existence. Once again the idea occurred that data compression techniques could be applied to all data sent by modem, and not just the occasional file. The MNP5 protocol not only provides error correction but also has built in data compression.

At this juncture politics took over. MNP protocols were rapidly establishing themselves as de facto standards, however they belonged to Microcom and manufacturers had to pay royalties in order to use them. This contrasted with CCITT standards which were freely available to all. The CCITT set to work at producing its own error correction protocol. It already had a protocol which it used for X25 packet networks. The error correcting part of X25, called LAPD, was modified for modem usage and became known as LAPM.

LAPM was to form the basis of the CCITT's standard for error correcting. However, a compromise was reached since many people were already using MNP. Microcom agreed to drop royalty charges on all versions of MNP up to and including level 4, and MNP4 error correction was included in V42 as 'the alternative protocol.'

By now things were really beginning to hot up and a real battle broke out over which scheme to follow for data compression. Dr Alan Clarke (who was working for BT at the time) modified an existing data compression algorithm which was eventually adopted as the V42 bis standard. The V42 bis algorithm was invented by two scientists – Lempel and Ziv – so Clarke's variation became known as BTLZ (BT's Lempel-Ziv).

BTLZ narrowly defeated Microcom's MNP5 for a number of reasons. For a start, it required less processing power than MNP5, making it possible to run BTLZ using an 8-bit chip like the Z80 or 6502 rather than a more expensive Intel or Motorola 16-bit processor. Another reason is that BTLZ required less memory.

In simple terms, BTLZ examines data as it is being sent and builds up a dictionary of abbreviations for any common patterns it discerns, which it transmits to the receiving modem. During the connection it is possible to modify the contents of the dictionary but BTLZ doesn't really require a large dictionary in order to work. MNP5 by contrast needs a bigger dictionary and takes more computer power.

THE FINAL HURDLE

V42 bis also solved another problem. PC users had cottoned onto the benefits of data compression long before modem manufacturers. One of the techniques which many file compression utilities employ is a variation of Lempel-Ziv, and something of a disaster therefore happens when a data compression modem encounters a file that has already been compressed by a similar algorithm. Frequently the end result is that the file is expanded rather than sent in its compressed form.

Consequently some bulletin board fanatics were turning off the MNP5 facility built into their modems and only using the error correction supplied by MNP4. What BTLZ did (with a little help from Hayes) was recognise when a file was already compressed and leave it alone!

The current state of play is that V32 bis modems rated at 14.4k bps are the fastest modems available. By utilising data compression techniques, which can compress some files fourfold, these modems are capable of transmitting at a top speed approximating to 38.4k bps.

The snag is that most serial ports fitted as standard to a PC can't cope with this throughput. If yours doesn't the solution is to fit a card that uses a fast serial chip called a 16550, although these cards can cost anywhere between £60 and £300.

For a review of four of the latest modems using these standards turn to page 234 ●

SOFTWARE RESOURCE

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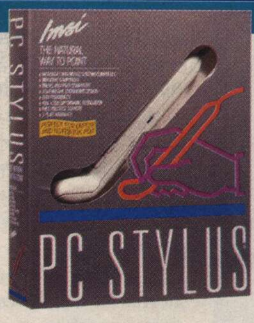

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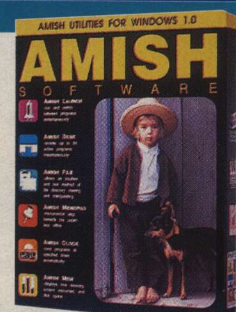

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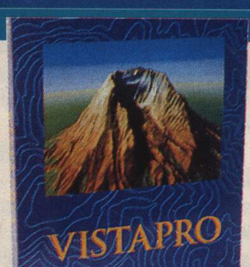
AMISH SOFTWARE



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